Vegetation Resources Inventory

Field Calibration Procedures for Photo Interpretation

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Major Changes to Field Calibration Procedures

1. Added GPS collection for the start, middle and end of ground and air calls so that extent and direction can be maintained for future inventory work. (Section 2.2.5 pg.6 and Section 2.3.1 pg.7)

2. Added wording to the field manual for systematically missed data collection. Example added describing missed D layers including rework and subsequent redo of Quality Assurance in the appendix section. (Appendix C pg.14)

3. Added wording to clarify Data collection and sample tree requirements for D layer. (Section 2.2.5 pg.7 and 2.3.2 pg.8)

4. Clarified wording to reflect that estimated data from observations are required to be written in the comment field and **not** in measured fields of the summary spreadsheet. (Section 2.2.5 pg.6)

5. Clarified wording to reflect that ocular species estimates are required to be recorded in the field labelled Ocular Species Comp within the final digital data summary form written in the comment field and **not** in measured fields of the summary spreadsheet. (Section 2.2.5 pg.6)

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1.0 Introduction

Vegetation Resources Inventory (VRI) field calibration consists of ground and air assessments conducted by photo interpreters on vegetated polygons. They are intended to provide calibration information for subsequent photo interpretation by the individuals conducting the field visitations and to provide the photo interpreter an iterative educational process to further increase their knowledge of the different vegetation types and site conditions in the project. Comprehensive land cover information is obtained through a detailed data-gathering routine. The data provide a useful link of vegetation attributes on the ground to how it is observed on aerial imagery, and thus aid in providing accurate and consistent attribute estimation.

Proper location and establishment of VRI calibration points is imperative to providing useful data sources for the current inventory and any subsequent inventories.

The following principles apply to the placement of VRI calibration points.

1. The collection of field calibration data must be distributed to cover the full range of anticipated land cover types to be observed, as well as areas identified as issues and of concern to the photo interpreter. Priorities for data collection may be identified on a project-by-project basis as per the project pre-work or Vegetation Project Implementation Plan (VPIP).
2. Calibration points are conducted to provide data to strengthen the final photo interpreted estimates.

The following are general requirements for calibration points establishment

1. All photo interpreters involved in the attribution stage of the project must participate in collecting air call and ground call data to enhance their knowledge of the different stand types and conditions within the project area. All photo interpreters working on the project are expected to complete a percentage of fieldwork in similar stand types that is comparable to the percentage of attribute estimation they are responsible for.
2. Collection of calibration data is to be conducted by a certified VRI photo interpreter, or under the direct supervision of a certified VRI photo interpreter.
3. Before field visitation, the photo interpreter should observe the calibration point polygon through stereoscopic vision and make preliminary estimates for all attributes. Following the data collection, the interpreter should review the initial estimates in comparison with the data obtained.

2.0 Calibration Points

There are three types of calibration points:

1. Observation
2. Ground call
3. Air call

Observations are not subject to the third-party quality assurance process. Ground calls and air calls are subject to the third-party quality assurance process.

2.1 Observation

Ground and air observations are an integral and highly useful data source for the photo interpreter. Efforts should be made to collect and record data while traveling between ground call and air call locations. All ground and air observation information can be collected on existing photos or orthoimages.

The location of observations is determined during the calibration process and is dictated primarily by the photo interpreter's need for additional calibration data in difficult forest types and can be as simple as a notation of species composition or height estimate in a polygon.

2.2 Ground Call

There are three ground call types that are considered acceptable for the collection of ground data for calibration purposes; 3-point ground calls, 1-point ground calls and observation ground calls. The types and number of ground calls established will vary by project and will be specified in the VPIP or project contract. It is expected that projects will use a combination of the three types of calls.

The proportion of each type of ground call is determined at the project planning stage. The lead proponent / licensee should consider the following factors when deciding on the proportions of each type of call: complexity of stands (uneven aged, multi species, variable heights, and variable density), age and distribution of previous data sources, and field work budget.

The photo interpreter must review the plot results before leaving the ground call (particularly in multi-species stand) and comment whether the plot data reasonably reflects the observed stand attributes. Based on an ocular observation of the representative portion of the stand, the interpreter should comment if a species composition adjustment is necessary to the species composition derived from the plot data. A comment regarding species composition adjustment is entered in the comment section of the final ground call digital summary.

Three Point (3-point) Ground Call (XGV)

The 3-point ground call consists of three plots with a minimum distance of 50 m between each plot. A reduction in the minimum distance is permitted in very small polygons. This type of ground call is typically used in complex stand with significant variation in stand attributes. For example, these include stands with multiple species, patchy tree distribution; uneven-aged or all-aged stands; multiple layers such as interior Douglas-fir stands; and a wide range of ages and/or heights such as mature spruce-balsam complexes. The 3-point ground call will provide more representative information on species composition, basal area, density, age, and height in these types of stands than a single point ground call.

One Point (1-point) Ground Call (XGV)

The 1-point ground call consists of one plot established in a representative portion of the polygon. This type of ground call would typically be used in very homogenous polygons with little variation in

attributes. Fire origin stands of lodgepole pine or stands of coppice aspen are good examples of where a 1-point ground call should be used. A brief walk and informal sweeps should be completed in the representative portion of the polygon before establishment of the plot center to ensure the most representative plot location of the polygon. Informal sweeps are not subject to quality assurance.

Observation Ground Call (XGO)

Ground observations with measurements are calibration points where ocular species composition estimate, age and height of the leading and second species, and additional comments to help the photo interpreter in the estimation phase are collected in the field. The photo interpreter should view the image stereoscopically before entering the polygon to estimate the basic stand attributes and then, take a short walk through the stand to confirm the species composition. Although sweeps are not required, it is recommended that a few informal sweeps be completed to improve species composition and basal area. The age and height of a suitable sample tree representative of the stand for the first and second leading species must be measured and recorded.

2.2.1 General Requirements for Ground Call Establishment

- All photo interpreters involved in the attribution stage of the project must participate in the ground calibration to enhance their knowledge of the different stand types and conditions within the project area.
- Ground call data collection is to be conducted by a certified VRI photo interpreter, or by someone under the direct supervision of a certified VRI photo interpreter.
- Ground calls must be located in representative areas of the polygon.
- All plots must be a minimum of 50 meters from any distinct polygon boundary to reduce the possibility of edge effect. These polygon boundaries include, but are not limited to, road rights-of-way, cut blocks, well sites, swamps and water features. A reduction in the minimum distance from a defined polygon boundary may be permitted in small polygons where the 50 m distance requirement cannot be met for a 1-point ground call or ground observation with measurements or the 100 m distance requirement for a 3-point ground call cannot be met.
- Tree measurement and recording of data should be systematic in nature (clockwise from north); at a minimum, the first tree measured in each plot should be numbered and all trees tallied ‘in’ should be marked with a paint dot or number at or near dbh.
- To assist with identification of plot trees and measurement of borderline trees, plot centers should consist of stakes firmly embedded in the ground with a ribbon around it and the plot number on the ribbon and, if it is a 3-point call, the point number (saplings and small trees are not acceptable).
- Ribbon must be used to indicate the tie point and the direction of travel to the plot centre and in between plots.
- Before leaving the ground call, the photo interpreter must complete all measurements, calculations and data summaries. The photo interpreter should carefully consider the data summary as it relates to the ecology and vegetation of the site before leaving the polygon.
- Tree count will be based on the measurement of the dominant, co-dominant and high intermediate trees in each layer in the polygon.
- For multi-layer stands, complete information is to be collected and recorded for each layer visible on the aerial image. The field crew should stereoscopically view the polygon prior to collecting any data to determine whether multiple tree layers exist within the polygon and identify these in the field plan. If there is more than one layer, the crews must write down in the column next to the tree number column on the field card which layer each tree belongs to.

- An observed and/or calculated dead layer consisting of 100 snags or more, is considered a separate layer and will require tally on all trees and sample trees on the leading species.
- An ocular species composition must be estimated for each ground call and the interpreter must comment if a species composition adjustment is necessary to the species composition derived from the plot data. A comment regarding species composition adjustment is entered in the final ground call digital summary.

2.2.2 Plot Types

Variable Radius Plot

- A variable radius plot should be used in stands where the average DBH is above 10cm.
- The desired tree count is 6 to 8 live dominant, co-dominant and high intermediate trees per variable radius plot on average over the project area. Once a BAF is selected it will be maintained throughout all of the plots in that polygon. There are open forest stands in the province that will not achieve the target minimum on an individual call.
- Borderline trees will have the diameter and horizontal distance measured to determine whether they are ‘in’ or ‘out’. This data should be recorded on the field cards to assist with quality assurance.

Fixed Radius Plot

- Fixed radius plots should only be used in stands where the average stand diameter is ≤ 10cm DBH.
- The optimum plot radius used should result in an average of 12 to 18 live trees per plot and must use one of the following plot radiuses: 5.64m, 3.99m, 2.52m or 1.78m.
- The plot size shall be maintained consistently for all fixed radius plots within the polygon.
- All trees within a circular plot must be tallied and used in all tree calculations and measurements. Splitting of plots or using only a portion of a circular plot to make attribute measurements is not permitted.

2.2.3 Sample Tree Selection

- Sample trees must be representative of the main canopy of the stand, typically the co-dominant and dominant trees for each layer. Trees should be free of MAJOR defects, for example:
  - significant broken top
  - significant dead top
  - fork or crook that significantly affects height growth
  - abnormally high amount of scarring or other damage that may have affected height growth [for example - significant mistletoe infection]
    - *Significant* refers to a reduction in the length of the tree compared to what it would be if undamaged. This is a subjective assessment without any defined percent height loss requirement. If the sample tree appears shorter than the majority of the other plot trees from the same cohort (species, crown class, diameter class, general age), then it would not be a suitable tree.
- At least one sample tree, for age and height measurements, must be selected for both the leading species and second species. If using a 3-point ground call, three leading species trees

and one second species tree must be selected over the three plots. A second species sample tree must be chosen for any composition equal to or greater than 1% as indicated in the final plot label.

- In a situation where the ocular species composition of the first and second leading species is different from the ground call mathematical calculated species composition; additional sample trees that meet the sample tree requirement for the ocular species composition must be collected. The ocular species composition was introduced primarily to capture the polygon minor species which in some cases is not captured in the ground call tree tally.
- Multiple layer stands will have a 3-point call with three sample trees of the leading and at least one of the second leading species for the main (rank 1) layer, and one of the leading and one of the second for each of all other layers, the main or rank 1 layer is defined as the tallest layer with a field estimated crown closure of greater than 10%, if none are over 10% then the tallest layer is considered the main layer.
- Dead layers require a single sample tree of the leading species to be collected. If the interpreter is unable to obtain a suitable age/height pair from a dead tree, they must take a comparable age/height from a live tree of the same species. A dead tree must be attempted prior to selecting a comparable live tree as an alternate.
- The same trees must be used for both age and height. Where sound sample trees are not available, trees with rot defect may be used and noted as an estimated age in the comments.
- All sample trees are to have an 'S' painted on them facing the direction that the height was taken.
- If there are no representative 'in' trees available, trees from outside the plot may be used as a sample tree. Trees should be numbered starting with 99 for the first sample tree and then 98 for the next sample tree and this sequence of numbering should be continued until all sample trees have been identified. A comment should be noted on the field card indicating the approximate bearing and distance from the plot center to the sample tree to assist the QA personnel in locating the sample tree(s).

2.2.4 Data Collection

The following information is to be recorded for each ground call:

- Crew Names; Company Name; Call type, Call Number, and number of points within the call.
- Date;
- Basal Area Factor (BAF): BAF size used to determine plot trees;
- Tallied trees
- Species: All tallied trees are to have genus and species recorded;
- Crown Class: Each tree will have its crown position identified in relation to the surrounding stand structure within approximately 25m of the extent of the call. In the case of a 2 layered stand, a tree's crown position must be identified in relation to the layer it represents.

  Category I - Dominant (D), Co-dominant (C), High-intermediate (H)

  Category II - Intermediate (I), Suppressed (S)
- Diameter at Breast Height (DBH): All tallied trees must have a recorded DBH. Accuracy required for DBH is as described in Appendix A. For procedures and examples of DBH measurements, refer to the VRI Ground Sampling (Phase 2) Procedures manual.

- Age: All sample trees must have an age. Age cores must be field counted and should be office verified using a hand lens or microscope. Field age counts (unless this is the only age provided) sample trees with prorated ages are not subject to the quality assurance standards. Age cores must be kept for possible office verification and quality assurance purposes.
- Height: All sample trees must have a height;
- Ocular Species Composition: Must be estimated in the representative area of the stand for every ground call and recorded separately in the comments section;
- Ecological Information: Record the dominant soil moisture regime (SMR) and soil nutrient regime (SNR) in the area of each ground call. In a one plot ground call, determine the dominant SMR and SNR within a 25m plot radius. In a three-plot ground call, determine the dominant SMR and SNR within a 20m strip of the ground call transect. The crew is encouraged to correlate the presence of all vegetation species (trees, shrubs, and herbs) with soil types and their moisture and nutrient regimes. Data on shrubs and herbs should only be collected if it will be visible from the image;
- GPS Coordinates: If the crew is unable to capture a field GPS coordinate of the location of the ground call, then an intended coordinate is recorded and labeled as “Intended”. Field captured GPS coordinates are labeled as “Field” coordinates.

2.2.5 Data Summary

A summary for each ground call must be made and include the following data, at a minimum:

- BCGS Map Sheet Number;
- Ground Call Number;
- Layer information: if more than one layer;
- Species composition: Species composition is determined on the basis of basal area of the Category I crown class trees (D, C, and H). For variable radius plots species composition is based on tree count. For fixed-radius plots, compute the individual tree basal areas and use them in determining percent composition;
- Ocular Species Composition - the ocular estimate must be recorded in the separately labelled Ocular Species Comp field within the final digital data summary form for 1-point and 3-point ground calls;
- Age: The average age of the leading and second species based on the office verified sample tree measurements. Field tally sheets must include the field age count. Ages estimated from rotten cores are not subject to QA standards;
- Height: The average height of the leading and second species based on the sample tree measurements;
- Basal area: Total basal area for the plot. If the interpreter feels that the tallied trees do not reflect the actual basal area of the stand, an estimate of the basal area should be made in the comments section;
- Density: Stems /hectare for all tallied trees. Density from field plots must be calculated as per the methodology outlined on the VRI field cards, or a formula accepted by Forest Analysis and Inventory Branch;

- Snag Frequency: Snags/ha;
    - If snags are ≥100sph, a Dead Layer must be identified as a separate layer and all the necessary attributes captured (species composition, leading species age and height, density, and basal area);
- UTM coordinates: All ground call locations are to be referenced to a Geographic Positioning System (GPS) location in UTM NAD 83 format. For a 3-point call, the center point should be used as the reference. If required for a project, or at the interpreter discretion, GPS data may also be collected at the start, mid and end points of a multi-point call, and recorded in the calibration tile.
- Comments: Add comments that help describe the stand (calibration data point) either under or in the canopy that will assist the photo interpreter during the photo estimation phase.

2.3 Air Call

Preliminary planning includes the creation, submission and approval of a field air calibration plan including a tally of air call targeted stand types. In this respect, initial polygon delineation for a project should be completed prior to the determination of field calibration locations.

All information collected will be recorded on the VRI Air Call Form or digital equivalent. The hardcopy forms or digital must be submitted to the Ministry upon completion of the field calibration. Summarized digital air call data must be submitted to the Ministry in an excel format.

2.3.1 General Requirements for Air Call Establishment

- A minimum of one British Columbia VRI Certified photo interpreter must be in the air craft during the collection of the data; although it is preferable to have two certified interpreters.
- Each interpreter should air call proportional number of project map sheets.
- Air calls must be located in representative areas of the polygon.
- All air call start, mid, and end-point locations must be referenced to a Geographic Positioning System (GPS) location so that they can be subsequently revisited for any quality assurance and accurately placed in the provincial field calibration tile. Positions for the start mid and end points may be determined using the field plan, GPS tracks or waypoints collected by the helicopter, but must accurately reflect the location, orientation and extent of the call.
- Data collected in air calls should be for the visible portion of the polygon (trees that are visible on the aerial imagery used for the project, shrubs and herbs not otherwise obscured by taller vegetation, etc.) This would normally include trees in the dominant, co-dominant and high intermediate canopy positions.
- Decisions about multi-layer stands should be made using the stereo image before going to the air call location. For multi-layer stands, complete information is to be collected and recorded for each layer visible.
- All of the data collected are to be estimates. It is important that the crews calibrate themselves with ground measurements to ensure the estimates are reasonable. The air call crew must set down to collect ground data approximately every 20 calls (and indicate in the records where this has occurred) to enable them to calibrate their estimations.

2.3.2 Data Collection and Summary

The following is required information is to be recorded for each air call:

- Crew Names; Company Name;

- Date;
- BCGS Map Sheet Number;
- Air call identification: Air call numbering should be formatted as follows: "Flight plan number – Air call number – Year". Assign each air call a unique air call number. Air calls should be numbered systematically for ease of reference;
- UTM coordinates: All air call locations are to be referenced to a Geographic Positioning System (GPS) location in UTM NAD 83 format;
- Layer information: if more than one layer;
- Air call information is based on dominant, co-dominant and high-intermediates trees only;
- Species composition: The tree species composition is determined on the basis of basal area and can include a maximum of six tree species. Each species indicated must have a corresponding percentage included;
- Age: Leading and second species age for the dominant and co-dominant and high intermediate crown position to the nearest 10 years;
- Height: Leading and second species height for the dominant and co-dominant and high intermediate crown position to the nearest metre;
- Basal area: For the dominant and co-dominant and high intermediate crown position;
- Density: For the dominant and co-dominant and high intermediate crown position;
- Snag frequency;
    - If snags are ≥100sph, a Dead Layer must be identified as a separate layer and all the necessary attributes captured (species composition, leading species age and height, density, and basal area);
- Comments: Add any comments that may assist the photo interpreter during the photo estimation phase.

The following is supplemental information that should be recorded for each air call:

- Shrub Height;
- Herb Cover Type;
- Non-Vegetated Cover Type.

Additional information can be collected at the interpreter's discretion.

3.0 Documentation of Calibration Points

For all final located ground calls and air calls, the minimum documentation must include the location, the extent and identification of each call. For quality assurance purposes field orthoimage showing field locations must be provided.

Ground Call

Upon completion of the ground call, the appropriate aerial photograph or orthoimage should be pin-pricked to mark the location of the ground call. The corresponding ground call documentation details should be noted near the location mark. A capture of the field GPS coordinate for the plot centre should be carried out and recorded on the field card.

For example, documentation for a three-point ground call (reference #3), established in 2008 is as follows:

GV 3(08)

I----------X----------I

Documentation for a single point ground call (reference #4), established in 2008 is as follows:

X GV 4(08)

Documentation for an observation ground call (reference #5), established in 2008 is as follows:

X GO 5(08)

Air Call

Upon completion of the air call, the appropriate aerial photograph or orthoimage should accurately mark the location of the call. The corresponding air call documentation details should be noted near the location mark. A capture of the field GPS coordinate for the start, mid and end points of the air call and ground call extent is necessary.

For example, documentation for an air call (call 21, flight plan 3), established in 2008 is as follows:

3-21(08)

|--------- X --------->

Any variation from the above requirements should be agreed to and documented during the project pre-work meeting. The photos or orthoimages and newly acquired ground call GPS coordinates must be made available to the quality assurance personnel.

4.0 Deliverables

4.1 Interim Field Deliverables

The following deliverables are required to be provided to the Ministry and QA personnel upon request. These may be required during the field work stage, in order to provide timely Quality Assurance results and feedback to field crews:

- A list of air and ground calls completed to date, including call number, call coordinates, and crew members
- Copies of Air call tally cards or digital equivalent (IE photographs of paper cards are acceptable at this stage);
- Ground call field cards, paper forms or digital equivalent (must be in a format that can be opened using MS Excel, notepad, or MS Word) containing all attributes that are required to be collected in the field as per the contract (including call type, call number, and number of points within the call).

Crews must be able to provide the above information on short notice (IE one or two days), as QA crews may be on site and require data promptly.

4.2 Final Field Deliverables

The final deliverables submitted to the Ministry must include:

- Air call tally cards or digital equivalent;
- Ground Call B.C. VRI tally cards (forms FS167A, B and C) or their equivalents (digital or paper) that include the same fields, including call coordinates.
- Summary of all ground calls and air calls data in a digital format provided by the Ministry that must include corrections from the Quality Assurance reports.
- A field calibration Personal Geodatabase file (including the same fields as the field calibration template) with the final location and the extent of established ground calls and air calls.

Appendix A – Ground Call Standards

Representative Location:	Ground calls must be located within a representative portion of the polygon. An interpreter must ensure that a call is representative of the polygon. If it is CLEARLY not representative of the polygon (gross error) then the call will be rejected. For example, if the calibration point is located in the only pocket of a specific label.
Establishment Location:	Field location of each ground call must be within ±30m of the provided coordinate.
Layer Identification:	The call must determine the correct number of layers in the stand. No error allowed.
Species Identification:	One error allowed in species identification for a three-point ground call. No species identification error allowed for one-point ground call.
Crown Class	The tree must be within the correct crown class category.
Age:	The counted ages for trees less than 300 years must be within ± 10% or 5 years, whichever is greater and for trees equal or greater than 300 years within ± 15% or 20 years, whichever is greater.
Height:	The measured sample tree heights must be within ± 5% or 0.5 m, whichever is greater.
Diameter Breast Height:	DBH for sample trees must be within ± 3% DBH for non-sample trees must be within ± 15% or 5 cm, whichever is greater.
Tree Count:	One-point ground call No errors allowed; Three-point ground calls must be within ±1 tree; Note - missed or added trees are cumulative (i.e. 1 missed tree and 1 added tree in a plot is a difference in tree count of 2).
SMR and SNR:	Correctly identified within ±1 class;
Basal Area and Density:	Must be correctly calculated based on the contractor's recorded dbh and pre-approved calculation formula and the number of trees tallied.
Ocular Species Composition:	At least 80% of species composition must be correctly identified at every ground call to achieve full points.
Suitable Sample Tree:	Must be of the correct species, represent the crown position of the average dominant and co-dominant of each layer, and be free of *major* defects. There are no errors allowed in the leading species sample tree selection in a one-point ground call and the sample will be rejected for payment. A score of zero for the suitable sample tree selection field will be assigned for that tree in the Ground Call Quality Assurance Rating Summary Form.

Inter Plot Distance: The inter-plot distance must be within +/- 10%.

Appendix B – Air Call Standards

Location:	Air calls must be located within a representative portion of the polygon and the GPS locations of each air call must be within the correct polygon.
Layer Identification:	The call must determine the correct number of layers in the stand (as would be seen in the photo). No error allowed.
Dead Layer:	Snags ≥100sph identifies a dead layer. Species composition, leading age and height, basal area and density must be collected.
Species Composition:	80% of species composition must be correctly identified.
Leading Species:	Leading species must be correctly identified. If the first and second species are within 10% by composition, then either species is acceptable as the leading species.
Age:	The age estimated must be within +/- 20% or 15 years, whichever is greater. Discretion should be applied with stands over 300 years of age.
Height:	The estimated heights must be within ± 15% or 3 m, whichever is greater
Basal Area:	Basal area must be within +/- 10m^2 per hectare or 20%, whichever is greater.
Density:	Estimated stems/ha must be within 100 stems or 20%, whichever is greater.
Snags:	Estimated snags/ha must be within 100 stems or +/- 20% whichever is greater

Appendix C – Quality Assurance Procedures

This Appendix contains the Quality Assurance Procedures for ground call and air call establishment based on the VRI Field Calibration Procedures for Photo Interpretation. This document is intended to be used by individuals responsible for the quality assurance of the field calibration stage of a VRI photo interpretation projects

Quality Assurance (QA) is a process, whereby the work is evaluated by assurance personnel using approved standards established for calibration point location and measurements. A rating system with pass/fail criteria has been developed to evaluate the audited calibration points and to determine if the calibration points were established to the current VRI standards.

The quality assurance results provide the contract administrator with information about the quality of the work being completed and the contract administrator will use the pass/fail criteria as the basis for payment of work.

The ratings outlined in Section 4 and section 5 of this appendix are used for evaluation of the three ground call types and air call as described in this document.

Systematic errors are reproduced inaccuracies that are made consistently in the delineation, attribution or field calibration stage over a project, portion of a project, or by a specific interpreter. These may be difficult to determine on an individual map basis.

An example of a systematic error would be where an interpreter has consistently missed calling D layers in beetle infected stands during the air call portion of field calibration. In this case, the quality assurance personnel may have noticed that an interpreter has missed one or two calls during the QA flight, but it does not affect the overall pass/fail determination for air calls. In a QA review of the air calls, it may become apparent that the missed D layer calls are more prevalent and is systematic (i.e., consistently being missed).

In instances such as this, the Ministry representative may require the contractor to re-work a portion or all of the calls and they are subject to further QA review.

1. Objectives of Quality Assurance

The objectives of conducting quality assurance of calibration points encompass the determination of both the effectiveness of the calibration points and accuracy of measurements.

Generally, the objectives can be stated as follows:

1. To provide feedback for improving the effectiveness of field calibration and the quality of field data;
2. To assess the performance of the individual interpreters;
3. To ensure adherence to the specified Ministry ground call and air call establishment standards; and
4. To provide supporting information for contract administration; i.e., to facilitate payment and to document the quality for future use of the data.

2. Quality Assurance Process Requirements

The following requirements must be adhered to during the QA process:

1. The QA is performed by a Certified VRI Photo Interpreter with significant experience who is independent of the primary contractor and sub-contractors that are undertaking the inventory project.
2. The QA person is an experienced individual capable of conducting quality measurements and assessments to ensure field procedures have been conducted within standards.
3. The QA person must be the person completing the quality assurance on all other phases of the project including the delineation, fieldwork and attribution phases.
4. The project coordinator notifies the QA person well in advance of the planned field start-up date. The initial quality assurance must commence in the early stage of field calibration work for each crew. The interpreters will benefit from and are encouraged to accompany the QA person in the field, especially on the initial inspections. A second quality assurance visit must be completed once all the field work has been completed to ensure the QA sample includes the entire population of ground calls.
5. Send all third-party quality assurance reports to the Ministry representative.
6. Every ground call and air call established in the project, as well as every interpreter's work must have a chance to be selected to undergo the quality assurance process.
7. QA a maximum number of 50 air calls in a day.
8. The QA ground call establishment must be carried out by a two-person crew. The contractor's attendance during the field QA measurements and review of air calls is strongly recommended however is not mandatory.

3. Procedures

The following are the general steps of the Quality Assurance process:

1. Ministry designates the Quality Assurance personnel at the commencement of the project.
2. Contractor and QA personnel develop schedule for submission of field work and scheduling of quality assurance visits.
3. Contractor completes field work and provides cards with supporting material to field locate the calibration points to the QA personnel.
4. QA personnel reviews calibration data and supporting materials in office and select calibration points for quality assurance.
5. QA personnel prepare QA report and submit it to the Ministry representative.
6. Ministry representative provides report to contractor.
7. If required, a meeting is coordinated with the contractor, Ministry representative and QA personnel to review report.

4. Data and Material Required

The contractor must provide the QA person with calibration data, air photos or orthoimages and any other supporting material that was used to locate the calibration points by the contractor's crews. This information will assist the QA person in locating the samples. A list of the final GPS coordinates of each calibration point must be provided. In addition, it is mandatory that all calibration points' locations are marked on the photos or orthoimages to enable points to be located without the assistance of GPS coordinates.

5. Office Check

An office evaluation of ground call and air call data in the batch must be completed before the QA person can proceed with the field inspection. If any of the data is missing, incomplete or errors are noted, the ground calls are returned for correction.

The QA personnel assesses the distribution of established ground calls and air calls and provides comments in the QA report on the distribution of the established calibration points versus the proposed distribution of calibration points in the approved Field Calibration Plan.

6. Calibration Point Sample Selection

Unless otherwise stated in the VPIP, a minimum random sample of five ground calls and air call or 5% of all ground calls and air calls established (whichever is greater) by interpreter, must be checked.

Ground Call

Batches of ground calls must be established in proportion to the type of ground calls and number of interpreters in the project. The criteria for defining a batch will be determined at the pre-work conference.

Inspected ground calls must be chosen randomly within each batch. Where safety or access restriction does not allow a ground call to be inspected, another ground call is randomly selected, and the reason for replacement is documented on the tally card.

Air Call

Batches of air calls must be established by flight plan and interpreter involved in the air call data collection. The criteria for defining a batch will be determined at the pre-work conference.

7. Field Data Check

It is recommended that the original field crew accompany the QA person in the early phase of the project. The following is a suggested process to follow during calibration point inspection:

Ground Call

1. Verify that the ground call location is:
    a. within the representative portion of the polygon;
    b. accurately marked on the photo or orthoimage; and
    c. within acceptable limits of the GPS coordinates.
2. Confirm that:
    a. adequate field markings of the tie point and tie line exist; and
    b. BAF size or plot radius was correctly selected.
3. Check accuracy of:
    a. plot tree count;
    b. tree measurements; and
    c. sample tree selection and measurements.
4. Provide comments:
    a. mandatory ocular species composition.

Where a ground call cannot be found in the field, the QA crew collects a GPS coordinate, and proceeds with checking the next available ground call in the area. Ground calls that cannot be located by the QA personnel score zero points on the ground call rating form and are removed from the calibration data.

Age Core Accuracy

It is expected that the QA personnel will attempt to get as accurate an age as possible. On trees that are not rotten, QA crews must re-bore if it is estimated that they are missing more than 2 years of core if less than 100 years old, and 5 years if greater than or equal to 100 years old. QA ages must be office counted.

Borderline Trees

Measured borderline trees will be assessed as follows:

- If the borderline 'in' or 'out' tree has been measured and the original 'in' or 'out' status using these measurements has been correctly calculated (i.e. a distance from plot center to the tree has been recorded and the tree has been calculated as 'in' or 'out' using the critical distance), the result will be accepted provided that the original critical distance calculated for the tree does not exceed one percent (1%) variation from the QA plot critical distance, and the original horizontal distance measured for the tree does not exceed one percent (1%) variation from the QA plot horizontal distance.
- This applies to borderline tree measurements only.
- Measured horizontal distance will be from the plot centre to the face of the tree at DBH, plus one-half measured diameter.

Air Call

5. Verify that the air call location is:
    a. within the representative portion of the polygon
    b. accurately marked on the photo or orthoimage
    c. within acceptable limits of the GPS coordinates.
6. Check accuracy of:
    a. air call estimates

Where an air call cannot be found in the field, the QA crew collects a GPS coordinate, and proceeds with checking the next available air call in the area. Air calls that cannot be located by the QA personnel score zero points on the air call rating form and are removed from the calibration data.

Calibration Data Transfer

Conduct a random 10% selection of air calls and ground calls and confirm that the calibration data transferred from the field cards to the calibration data summary table is completed correctly. The QA results are based on the percentage of calibration points that are transferred free of any error for each batch of air calls and ground calls checked.

8. On-site Reporting of QA Findings

The preliminary QA results must be presented to the Ministry representative as soon as practical following the field inspection.

In cases where the QA is carried out while the contractor is still at the project site, the contractor must be advised whether the completed work met the standards and is acceptable prior to the QA person's departure from the project site.

Where the QA person identifies substandard work, remedial actions must be provided to the project coordinator prior to the contractor leaving the project site.

9. Dispute Resolution Process

Where a dispute arises between the photo interpreter and the quality assurance personnel, the Ministry representative is responsible for developing a mechanism to resolve the disagreements.

10. Quality Assurance Report

Feedback from the QA person is important for the continual improvement of the calibration process and ground call establishment. The report should document any problems identified during the field review in order for the interpreter to be aware of areas of weakness to consider during the estimation phase and for improving ground data collection in the future.

Each Quality Assurance report must include the following:

1. Completed rating table (Table 1 and/or Table 2) for each batch (interpreter) of ground calls and air calls. For plot tree counts, QA contractor must provide borderline measurements for any missed or added trees as part of report documentation;
2. Any observations and considerations data users should be aware of regarding the data collected;
3. If required, a description of the recommended remedial action and a report on compliance with that direction; and
4. The QA person's signature and recommendation of acceptance or not acceptance of the work.
5. Air call tally cards or digital equivalent and Ground Call B.C. VRI tally cards (forms FS167A, B and C) or their equivalents must accompany the Quality Assurance report.

As well as providing immediate feedback to the contractors and Ministry, the results of the Quality Assurance process are included as part of the Project Completion Report deliverable.

11. Remedial Action Procedures

Where the outcome of the quality assurance identifies a need for re-work, all ground calls in the affected submission must be revisited to correct errors identified. Once the rework has been completed, a second QA on the resubmitted ground calls will be required to ensure the work meets MFR standards.

12. Ground Call Ratings

The ground call evaluation process is based on the assumption that all field cards are properly filled out and ground call locations are documented on photos or orthoimages, as outlined in the ground call data collection procedures. If the tally cards are found incomplete and/or ground call locations are not documented to the set standard, the batch submission will be returned to the field crew for completion.

Location representative of polygon	2
Established within ±30m of the provided photo or orthoimage marked location	2
Correct determination of single or multi-layer stand (as would be observed from a photo)	1
Tree count (based on all points within the ground call)	5
Sample tree DBH (0.5 points deducted for each error to a maximum of 1)	1

Non Sample tree DBH (0.5 points deducted for each error to a maximum of 1)	1
Suitable sample trees selected (1 point assigned for each sample tree)	1-4
(1 point deducted for each unsuitable tree)	
(4 points deducted from the total points obtained for a missed sample tree)	
Species identification (based on all points within the ground call)	5
Crown Class (90% of the trees must be in the correct crown class category)	2
Age (2 points assigned for each sample tree, 2 points deducted for each error)	2-8
Height (2 points assigned for each sample tree, 2 points deducted for each error)	2-8
SMR and SNR (1/4 point assigned for each)	0.5
Basal Area	1
Density	1

Ocular Species Composition*	3	≥80% correct
	1	>70% correct
	0	<70% correct

**Species Composition Examples:*

Quality Assurance	Contractor	
$S_{40}Pl_{30}Bl_{30}$	$Bl_{40}S_{30}Pl_{30}$	Species composition correct=90%;
$Fd_{50}S_{40}Pl_{10}$	$S_{50}Fd_{40}Pl_{10}$	Species composition correct=90%;
$Pl_{60}Fd_{30}Lw_{10}$	$Fd_{55}Lw_{25}Pl_{20}$	Species composition correct=60%;

Note: For contracts where additional data will be collected as described in the contractor proposal above and beyond what is required by standard ground call data collection (e.g. ages, heights), a maximum of one extra sample tree in each plot for the ground call will be quality assured. Extra sample trees subject to QA must be randomly selected and will be reflected in the scoring.

For example, a three-point ground call with data collected for more than the standard four sample trees will be quality assured for up to three additional sample trees, with points assigned as per the ground call ratings. Maximum points cannot exceed 14 points per attribute and ground call.

Ground Call Accept/Reject Criteria

The following are the accept/reject standards for each QA batch:

1. All categories must achieve 85% to be considered acceptable.
2. The minimum acceptable rating on any individual ground call is 75%. Any ground call not meeting this minimum percentage will be rejected and not accepted for payment.

13. Air Call Ratings

The air call evaluation process is based on the assumption that all air call data sheets are filled out and air call locations are documented on photos or orthoimages, as outlined in the air call data collection procedures. If the data sheets are found incomplete and/or locations are not documented to the set standard, the batch submission will be returned to the field crew for completion.

Location representative of polygon	2
GPS Location within the correct polygon	2
Correct determination of single or multi-layer stand (as would be observed from a photo)	1
Species Composition points	7 ≥80% correct
	4 ≥70% correct
	0 <70% correct
Correct Leading Species	6
Leading Species Age	2
Leading Species Height	5
Second Species Age	1
Second Species Height	3
Basal Area	1
Density	1
Snags/ha	1

**Species Composition Examples:*

Quality Assurance	Contractor	
$S_{40}Pl_{30}Bl_{30}$	$Bl_{40}S_{30}Pl_{30}$	Species composition correct=90%;
$Fd_{50}S_{40}Pl_{10}$	$S_{50}Fd_{40}Pl_{10}$	Species composition correct=90%;
$Pl_{60}Fd_{30}Lw_{10}$	$Fd_{55}Lw_{25}Pl_{20}$	Species composition correct=60%;

Air Call Accept/Reject Criteria

The following are the Ministry accept/reject standards for QA batch:

1. The minimum acceptable rating on any individual air call is 75%. Any individual air call not meeting this minimum percentage will be rejected.
2. Each category must achieve an overall rating of 80% to be considered acceptable. Any category that does not achieve this minimum standard will be rejected for that category.

Appendix D – Field Calibration Plan Guidelines

Objectives

Field Calibration Plans (FCP) are required to ensure consistency between the proposed field calibration points and the requirements for additional information in the project area.

a) Data source analysis from previous inventories. This is carried out to indicate where data sources may be considered less reliable or non-existent.

b) Consultation with proponents regarding management concerns.

The FCP will include calibration points that will assist the photo interpreter to correlate the vegetation attributes on the ground with those on the air photos (e.g., complex multi-layered stands). The actual field locations established in the field must still cover the stand types, geographic spread, etc. as described in the approved plan. At least 75% of the plots identified in the plan must be actually located in the field within 200m of the planned location. The 25% allowances permit crews to identify stands of interest in the field and be allowed to establish calls in these areas. Geographic dispersion and stand complexity representation will still be maintained. **If less than 75% are within 200m, then the additional plots that do not meet the 75% criteria will not be paid.** For example, if only 70% of the calls fall with 200m, without justification and prior approval by the Ministry, 5% of the total air or ground calls (as appropriate) will not be paid.

Approval process and plan content

Prior to the commencement of any field data collection, the contractor must submit to their respective Ministry project representative the FCP for approval. After successful review, written approval must be provided to the contractor. The plan must include:

a) An Excel spreadsheet showing the distribution of calls by age class, leading species and any calibration points pertaining to items identified in the VPIP. An example of field calibration table summary is shown in attached Table 3.

b) The number and type (1point and/or 3-point clusters) of calibration points proposed. Often more points than required to meet the target may be pre-selected to allow for operational issues such as limited access.

c) Designated staff who will be carrying out the field work including both air and ground calls.

Mapping Requirements

a) A submission format of a single shape file (.shp) for each call type.

b) All map sheet boundaries and map sheet ID.

c) Include the following map features:

- Proposed Air Calls with call #
- Proposed extents for air calls
- Proposed Ground Calls with call # and number of points, any identified multi-layer stands

  *Call numbers for air and ground calls established in the field must match the call numbers in the field calibration plan. Calls added in the field not in the calibration plan will be assigned new numbers.

Table 1 – Ground Call Quality Assurance Rating Summary Form

Project: _____ **Contractor**: _____

Number of Ground Calls Completed: _____ Number of Ground Calls Checked: _____

XGV #	Rep. Location (2*)	Location (2*)	Tree Count (5)	Num Layers (1)	Meas. Dbh (1)	Est. Dbh (1)	Suitable Sample Tree (1-4*)	Sp. ID (5)	Crown Class (2)	Age (2 to 8*)	Height (2 to8*)	SMR/ SNR (0.5)	Basal Area (1)	Density (1)	Ocular Species Comp. (3*)	Points Possible	Points Obtained	%
Total Points Obtained																		
Total Points Possible																		
Rating (%)																		

* Only categories scored for ground observation with measurements (XGO)

Each Category must reach a minimum score of 85 %
If the 85% criteria for each category has not been met, and between 7 and 11 calls have been selected for audit, then two (2) errors are allowed per category.
When 2 to 6 calls have been selected for audit, one (1) error is allowed per category.
When only a single call is selected for audit, the overall percent for that call must be equal to 75% for the batch to be accepted, and category ratings do not apply.

Comments:

Interpreter:_____ QA personnel:_____

Date:_____ Accept: _____

(Yes/No)

Table 2 – Air Call Quality Assurance Rating Summary Form

Project:_____ **Contractor:**_____

Batch Number	Air Call Number	Location Rep. (2)	GPS Location (2)	Num Layers (1)	Species Comp (7)	Leading Species (6)	Leading Age (2)	Leading Height (5)	Second Age (1)	Second Height (3)	Basal Area (1)	Density (1)	Snags (1)	Points Possible	Points Obtained	Rating (%)
Points Obtained																
Points Possible																
Rating (%)																

Interpreter:_____ Auditor:_____ Date:_____ Accept: _____(Yes/No)

Each Category must reach a minimum score of 80 %

Table 3 – Field Calibration Table Summary

Ground Calls	Age Class 1 1-20				Age Class 2 21-40				Age Class 3 41-60				Continue Age Classes	Non Forest		
Existing Species	Total XG	%	Area	%	Total XG	%	Area	%	Total XG	%	Area	%		Total XG	%	Area
SUM																

Air Calls	Age Class				Age Class				Age Class					Non		
Existing Species	Total XV	%	Area	%	Total XV	%	Area	%	Total XV	%	Area	%		Total XV	%	Area
SUM																

Existing Profile By Area							Ground		Air		Total Calls	
Species			Hectares	%	% no NF		# of Calls		# of Calls		# of Calls	%
Estimated Site Index > 0 but no Species 1												
Non Forest												
SUM												
Sum Excluding Non Forest												

List all leading species in the project as per the existing inventory. Species that are a very small portion of the profile may be grouped.
Show the number of calls to be established by each species in each age class.sp
Calls in each species as a percent of the total in THIS Age Class (not of the entire project)
Area in hectares in each species by age class
Area in each species as a percent of the total in THIS age Class (not of the entire project)
This summary is based on the existing forest cover so calls may be desired in areas where new delineation would determine treed label
Expressed as a percent of the TOTAL calls or area for the entire project
Normally we would not establish calls in non forest, so this column excludes the non forest hectares.
This may make a better comparison between the overall air and ground call totals by species.

Appendix E – Enhanced Ground Call Procedures

Objectives

Enhanced Ground Call Procedures have been developed as an option for projects where additional height and diameter information is required. The following procedures can be used on a project specific basis.

VRI Ground Call procedures will apply, with the following modifications:

- Raw tree data will be required for each ground call, data must be provided in a Microsoft XLS or XLSX format. CSV files will also be permitted providing that NO COMMAS are present INSIDE any data fields (including comments). A file structure is provided in this Appendix C below.
- All 1-point and 3-point ground calls in the project area must be established as *enhanced* ground calls
- For BAF selection, the desired tree count is 6 to 8 live dominant, co-dominant and high intermediate trees per variable radius plot on average. Once a BAF is selected it will be maintained throughout all of the plots in that polygon.
- All trees must have heights and DBH's recorded (Live and Dead)
- All trees must have an identified live or dead status
- All trees must be identified with a crown class (D, C, H, I, S). H = High intermediates, all other intermediates code as I
- The VRI calibration tile excel sheet will be derived from trees that fall within the D, C and H crown classes.
- Diameter limit will always be 7.5cm DBH
- Raw field cards or digital field data from Handhelds (as appropriate) will be provided by the contractor to audit entry into the raw tree data MS Excel template, and for field quality assurance.
- Collect GPS location data at the mid-point to accurately locate the point for QA and validation purposes.
- Heights on trees with a broken top will be measured to the break (not projected to an approximate unbroken top). Record a "B" in the broken top column where appropriate.

Regular compilation of ground call data for photo interpretation and calibration summary sheets will be the responsibility of the contractor.

In addition to standard audited sample trees, 10% of the heights and diameters in the call will be randomly selected for audit using the height and diameter sample tree standards (as per Appendix A). The scoring will be recorded in the scoring table shown below. The estimated diameter scoring in the standard scoring scheme will no longer apply.

Notwithstanding the above, existing VRI standards apply for all other attributes.

Table 1. Ground Call Data Template

Call_Number	Point_Number	Mapsheet	BAF	Diameter_Limit	Tree_Number	Species	Live_Dead_(L/D)	Layer	Diameter	Crown_Class	Height	Broken_Top	Age	Inter_Plot_Bearing	Inter_Plot_Distance	UTM_Zone	Easting	Northing	Comments
123	1	092I069	5	7.5	1	PLI	L	2	17.1	I	13.7	N		126	50	10	543210	4567890	
123	1	092I069	5	7.5	2	FDI	L	1	49.0	C	39.2	N	135						
123	1	092I069	5	7.5	3	PLI	L	1	46.4	C	37.1	N	120						
123	1	092I069	5	7.5	4	PLI	L	1	51.4	D	41.1	N							
123	1	092I069	5	7.5	5	PLI	L	1	30.5	C	24.4	N							
123	1	092I069	5	7.5	6	PLI	D	D	24.1	-	19.3	Y							
123	2	092I069	5	7.5	1	PLI	L	1	35.3	C	28.2	N	124	126	50				
123	2	092I069	5	7.5	2	PLI	D	D	35.9	-	28.7	N							
123	2	092I069	5	7.5	3	PLI	D	D	28.3	-	22.6	N							
123	2	092I069	5	7.5	4	PLI	L	1	44.3	C	35.4	N							
123	2	092I069	5	7.5	5	PLI	L	1	47.0	C	37.6	N							
123	2	092I069	5	7.5	6	PLI	D	D	13.0	-	10.4	N	80	123					
123	3	092I069	5	7.5	1	PLI	L	2	14.6	I	11.7	N		126	50	10	543210	4567890	
etc.																			

Notes: All enhanced calls will be recorded on the same excel sheet. UTM zone, easting and northing only needs to be recorded on one tree line, not repeated for all trees in the plot

Enhanced Ground Call Quality Assurance Rating Summary Form

Project: _____ **Contractor**: _____

Number of Ground Calls Completed: _____ Number of Ground Calls Checked: _____

XGV #	Rep. Location (2*)	Location (2*)	Tree Count (5)	Num Layers (1)	Sample Dbh (1)	Enh **. Dbh (0.5)	Suitable Sample Tree (1-4*)	Sp. ID (5)	Crown Class (2)	Age (2 to 8*)	Sample Height (2 to8*)	Enh ** Hgt (1)	SMR (0.25)	SNR (0.25)	Basal Area (1)	Density (1)	Ocular Species Comp. (3*)	Points Possible	Points Obtained	%
Total Points Obtained																				
Total Points Possible																				
Rating (%)																				

* Only categories scored for ground observation with measurements (XGO)

** Extra enhanced heights and diameters

Each Category must reach a minimum score of 85 %. Comments:

Interpreter:_____ QA personnel:_____

Date:_____ Accept: _____

(Yes/No)